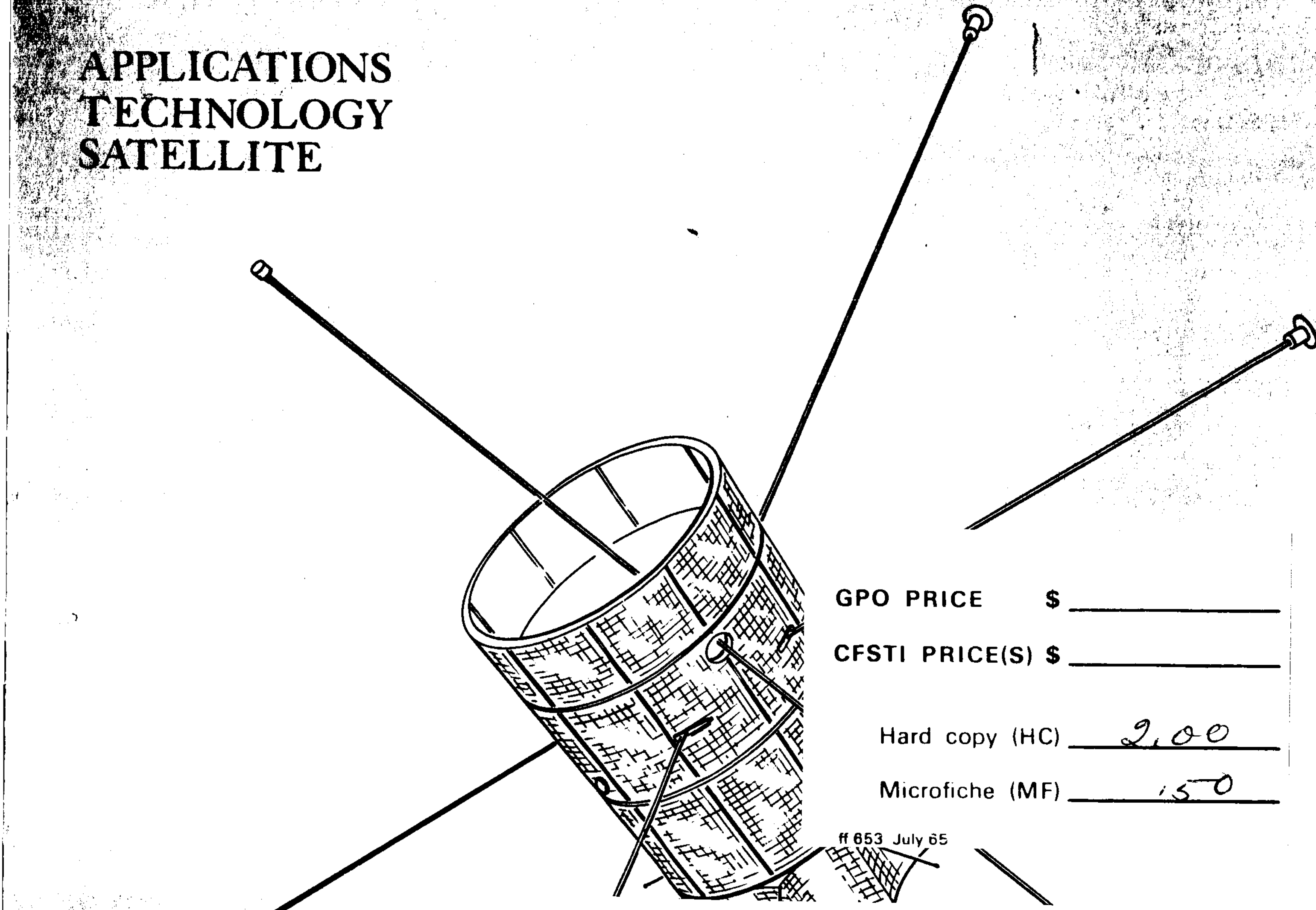
GRAVITY GRADIENT STABILIZATION SYSTEM for the APPLICATIONS TECHNOLOGY SATELLITE

DOCUMENT NO. 65SD4217
10 FEBRUARY 1965



SEVENTH MONTHLY PROGRESS REPORT

NASA CONTRACT NAS 5-9042

GENERAL ELECTRIC
SPACECRAFT DEPARTMENT

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GRAVITY GRADIENT STABILIZATION SYSTEM FOR THE APPLICATIONS TECHNOLOGY SATELLITE SEVENTH MONTHLY PROGRESS REPORT

1 JANUARY THROUGH 31 JANUARY, 1965

CONTRACT NO. NAS 5-9042

FOR THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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SECTION 1

INTRODUCTION

1.1 PURPOSE

This report documents the seventh month of progress toward the design of the ATS Gravity Gradient Stabilization System. The report covers the period from January 1 to January 31, 1965.

1.2 SCOPE

Under Contract NAS 5-9042, the Spacecraft Department of the General Electric Company has contracted to provide Gravity Gradient Stabilization Systems for three Applications Technology Satellites: one to be orbited at 6000 nautical miles and two to be orbited at synchronous altitude. The gravity gradient stabilization systems will consist of the stabilizing boom and dampers, attitude sensors, and power control and interface electronics.

SECTION 2

WORK PERFORMED

2.1 SYSTEMS ANALYSIS AND INTEGRATION

2.1.1 G^2S/ ATS MATH MODEL

Work has been initiated on the G^2S/ ATS Mathematical Model. The completion date (including complete program de-bugging) is scheduled for September 30, 1965. Design analysis effort, during the interim period of Math Model development, will continue to employ the more limited capabilities of the GAPS III program with gradual phase-over into use of the Math Model as various portions of that program are completed.

2.1.2 ATTITUDE DETERMINATION PROGRAM

Work has been initiated on an Attitude Determination Program Design Specification. However, primary emphasis is currently being placed on the completion of the sensor system error analysis. Equations for the solar aspect sensor/antenna polarization measurement system have been derived and are currently being programmed for numerical evaluation on the computer. A 3-sigma measurement accuracy of 1 degree will be assumed for initial evaluation of the antenna polarization measurements. However, this is a highly optimistic assumption when related to published results of an analysis of Syncom II data ("Syncom II Polarization-Angle Data Analysis", David T. Mott, NAS 5-3318, July, 1964). The relatively large spread of data (greater than 5 degrees) is attributed mainly to human error (operator technique). Hopefully, these errors can be significantly reduced by automation. Automation will also greatly enhance the system for ground data processing by automatically providing data in a form compatible with current concepts of data transmission (teletype and binary-coded magnetic tapes) for other spacecraft attitude sensors. Equations for the solar aspect sensor/ earth sensor measurement system will be developed through modifications to the RF sensor/ earth sensor equations described in the Second Quarterly Report, GE Document No. 65SD4201, dated 10 January 1965. Numerical evaluation depends on the accuracies associated with the particular earth sensor to be used (GFE IR sensor, the Nimbus horizon scanner, GE's Albedo sensor, etc). Also under consideration for attitude determination are the TV camera and the star field readers. The TV camera offers the most attractive means for quick look data at the ground stations (1-degree accuracy on pitch and roll angles less than 20 degrees and 10-degree or better accuracy on yaw measurements using the earth shadow line for reference). The star field readers (either the previously proposed GFE star field reader or a specially developed TV sensor for star field reading) offer the best possibilities for more accurate attitude determination (to the order of 0.2 degrees) at the expense of increased cost and complexity of ground data processing.

2.1.3 ORBIT TEST PLAN

Complete data system flow charts have been prepared for a meeting with NASA/ GSFC in the early part of February. The objective of these discussions will be the resolution of NASA/ GE data processing interfaces. Flow charts include the proposed "quick look" data system and estimates of turn-around time for both quick look data and weekly data reduction. Preliminary requirements for data formats are also included.

2.1.4 ORBIT TEST SIMULATION EXERCISE

Flow charts have been prepared to illustrate current concepts for the Orbit Test Simulation Exercise. These will also be presented at the same February meeting with NASA mentioned in paragraph 2.1.3.

2.1.5 SYSTEM REQUIREMENTS STUDIES

A systems Requirements Specification document for the GE Gravity Gradient Stabilization System is being formulated. When complete, the specification will cover both hardware and software requirements.

2.1.6 ANALYTICAL STUDIES AND RESULTS

2.1.6.1 Capture Studies

Preliminary MAGGE capture studies have been completed. Final studies will be delayed until a better definition of the following critical parameters are obtained:

1. Basic requirements for delay time between separation and initial boom deployment.
2. Initial spacecraft moments of inertias (prior to boom deployment).
3. Basic parameters of the new MAGGE configuration based on results of current optimization studies (after boom deployment).

Results to date are being documented for inclusion in the next Quarterly Report. Primary results of these studies are the following:

1. The requirement for a delay time between separation and initial boom depolyment has introduced a critical problem in assuring upright capture if the system is constrained to 100 foot initial boom deployment lengths and the initial spacecraft moment of inertia levels reported by HAC as of January 1, 1965.* Under those constraints, upright capture is marginal with zero delay time. A reduction of initial moments of inertia (to a level comparable to the earlier estimates of 67.5 slug-ft^2, or lower) will allow the incorporation of some finite delay time allowance. However, the best probability of upright capture is achieved if the requirement for a delay time is minimized.
2. Initial deployment of the X-booms to their full 150 foot capability (with subsequent retraction to 100 feet after capture, if desired) will substantially improve the probability of initial upright capture.

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*I_P = 74.1, I_R = 73.4, I_Y = 73.4

3. Inertia "growth", during deployment of the boom system, is the critical parameter during capture. Thus, capture studies are extremely sensitive to changes in initial spacecraft body inertias (prior to boom deployment) and final spacecraft inertias (after boom deployment).

The basic requirement for a delay time between separation and boom deployment needs further definition. The NASA imposed requirement to consider such a delay time is based upon a possible long tailoff characteristic at termination of Agena second burn which could create a residual Agena velocity increment after separation if separation occurs too soon after Agena second burn cutoff. However, Hughes Aircraft Company, in their Monthly Progress Report No. 4, is accounting for this possibility by extending the dwell time between Agena second burn cutoff (AZCO) and separation. This approach is preferred over the requirement for a delay time after separation since it has the minimum effect on assuring upright capture after separation. The Agena retro-maneuver (described in the HAC "Spacecraft Separation Sequence" plans, First Quarterly Progress Report, SSD4378R) should provide additional assurance that the 3 ft/sec separation rate is adequate for the preclusion of any interference between the Agena and the spacecraft booms during initial deployment. This is especially true if the damper boom is deployed after completion of the X-boom deployment.

2.1.6.2 Inversion Studies

Inversion studies to date have been concerned mainly with use of the HAC subliming rockets. Page 2-59 of GE's Second Quarterly Progress Report recommends a thrust level of "4.2×10^{-4} pound with an allowable tolerance of $\pm$ 15 percent." This statement contained typographical errors and should have read "3.3×10^{-4} pound with an allowable tolerance of $\pm$ 14 percent." This corresponds to a 2.3-hour inversion maneuver time. Subsequent studies (to be documented in the next quarterly report) reduced the tolerance band to ± 10 percent. These latter studies considered the effects of non-identical thrusters whereas the former studies assumed identical thrusters.

2.1.6.3 Optimization Studies

During the past month, GE initiated an optimization study in response to a request by NASA to establish an improved set of ATS configuration parameters for a more optimum steady state pointing accuracy and increased yaw stiffness for synchronous attitude missions. The program for accomplishing this study was recently completed and de-bugged, and the optimization studies are in progress.

2.1.7 TEST REQUIREMENTS AND PERFORMANCE

New acceleration and revised vibration test requirements have been established for ATS Components. These requirements have been revised to conform with Revision A of NASA Specification S2-0102, dated December 12, 1964.

In order to evaluate the performance of GGSS Components under realistic orbit thermal cycling, a solar vacuum test is proposed under the following conditions:

1. Use of a simulated sun
2. Rotation of the component under the extreme thermal conditions of SAGGE and at the same rotational speed
3. Housing the component in a thermally controlled environment representative of the Hughes structure
4. Installation of temperature sensors on the component and housing
5. Test chamber pressure established at 10^{-5} Torr or lower.

The Solar Aspect Sensor, TV Camera, and the Damper and Boom Assembly are being considered for the solar-vacuum evaluation.

2.2 BOOM SUBSYSTEM

2.2.1 SECONDARY BOOM DEPLOYMENT

A dynamic envelope drawing for the secondary boom (GE Dwg 47-207099) and the companion information (GE Dwg SK56152-103) were prepared to delineate the free space clearance required by the Damper Boom to allow for proper boom deployment and motion about the damper axis. The drawings are reproduced in the Seventh Monthly Interface Report, GE Document No. 65SD4218, for information.

2.2.2 CLUTCHING

A single rotary solenoid has been selected to actuate the clutch mechanism in place of the two linear solenoids previously considered. One of the advantages of the rotary solenoid is that it will draw significantly less power than the previous design. As a result of the meeting with NASA/GSFC at deHavilland on 6-8 January, a redundant indexing wafer will be added to the clutch rotary solenoid to ensure positive solenoid operation. The design will be implemented on prototype and flight hardware.

2.2.3 SCISSORING

In order to minimize dynamic boom deflection expected at the previous scissoring rate of 1/2 degree per second, the nominal primary boom scissoring rate will be changed to 1/8 degree per second. This will be accomplished by a change in motor gearhead. The boom package envelope will be increased slightly as a result of the change.

2.2.4 STRUCTURE AND MATERIALS

The first report covering materials proposed for use in the damper boom package was submitted by deHavilland in accordance with provision in the Boom Subsystems Specification, SVS-7316. GE is presently evaluating this material information to determine suitability for use in the Boom Subsystem structure. Results of this evaluation are expected in February. Subsequent materials reports are expected from deHavilland as the design is further defined.

2.2.5 ENVIRONMENTS

In a conference telephone call held between NASA/GSFC, General Electric and Hughes Aircraft representative, GE requested HAC to supply a better definition of the thermal environment provided by the current MAGGE and SAGGE spacecraft for the Boom Subsystem components. Based on the data HAC verbally supplied in the conference, GE has initiated a thermal analysis to determine actual thermal profiles for Boom Subsystem components.

2.2.6 TELEMETRY

It has been determined that a direct readout pressure transducer will be the most economical approach from an overall system standpoint. Selection of a specific sensor is in process.

2.2.7 PRIMARY BOOM

The length of the primary booms has been changed to 150 feet. Tip weights associated with these booms are 10 pounds for SAGGE and 2.5 pounds for MAGGE. The damper boom length is unchanged. A summary of the advantages of using 150-foot primary booms was presented in the "Second Quarterly Report," GE Document 65SD4201, dated 10 January 1965.

2.2.8 TIP TARGETS

In order to simplify the design of the boom tip target attachment, it has been proposed that the tip targets remain fixed to the booms at the angle required for stowage, flush to the vehicle "skin" during boost. This angle has been determined to be 50 degrees to the rod centerline. The target orientation is currently the subject of analysis to determine compatibility with the TV Camera Subsystem.

2.2.9 SECONDARY BOOM

A new cable cutter assembly will be used in the erection sequence for the damper booms. The cable cutter assembly will eject the connector concurrent with guillotine actuation; it will not be necessary to eject the entire cutter assembly.

2.3 COMBINATION PASSIVE DAMPER

2.3.1 SUMMARY

Efforts for the month have generally been concentrated into five areas.

1. Progressive tradeoffs to establish a detail layout of the CPD from the basic concept stage
2. Detail design and fabrication of a GE hysteresis damper model for engineering evaluation
3. STL hysteresis damper proposal evaluation
4. Preliminary design criteria for the Thermal Model (T-2) and the Dynamics Model (T-4)
5. Continued development testing

2.3.2 DESIGN EFFORT

2.3.2.1 General

The CPD package design effort was directed toward a more detailed study of the various parts previously shown in concept form only. In addition, several other factors affected the final CPD design:

1. More information relative to thermal requirements became available which required basic changes in the boom/damper interface area to allow space for soft insulation. It was previously assumed that a thin thermal shield would be sufficient.

2. Boom extension monitors (two switches) were added to the damper to indicate that the damper booms had been released. The addition of these switches resulted in minor changes to the damper base plate plus additional electrical circuitry in the CPD.

3. Because of a recent requirement for paralleling certain conductors from the connectors and for grouping grounding leads to the pyrotechnic devices, terminal boards are now necessary within the package.

4. It was decided to locate the angle detector electronics package outside the CPD package because of its size and for thermal reasons. This package was previously assumed mounted inside the CPD package.

5. The GE hysteresis damper concept was revised from the former structurally integrated configuration (with CPD structure) to a separate component form.

6. Structural computer runs revealed excessive deflections within the CPD structure which required some redesign effort to alleviate.

All the above factors plus the normal detail tradeoffs are being considered in the establishment of a final layout design for the CPD.

Work has been discontinued on a damper alignment device (provided to enable "aligned" clutching at a boom angle other than null in a "locked boom" emergency) because it was concluded that damper alignment cannot be provided without severely increasing the complexity of the clutching mechanism. Anticipated failure modes can be solved by a logical sequence of clutching and declutching operations that can be initiated through the command link. A detailed procedure for this operation will be prepared at a later date.

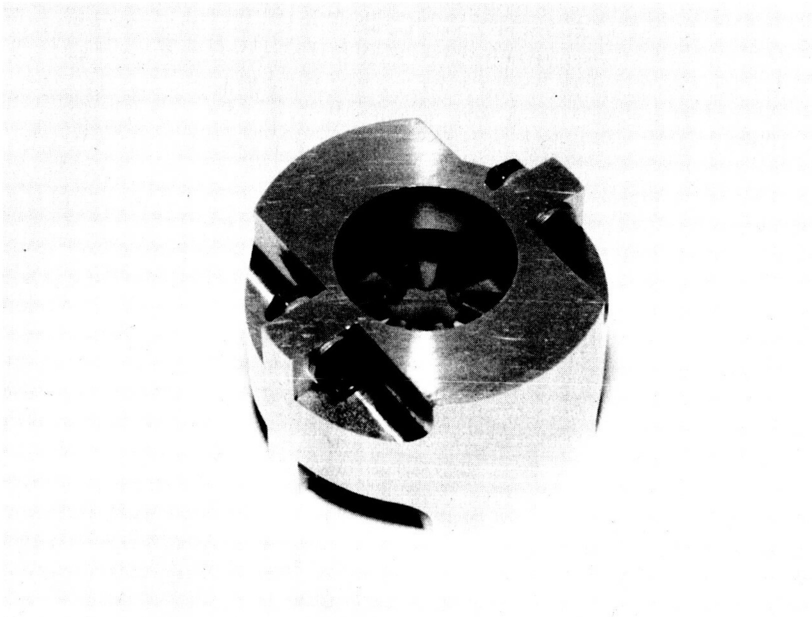
2.3.2.2 Diaphragm Clutch

Evaluation of the modified "Belleville washer" or diaphragm concept as the damper/ boom switchover mechanism was continued. Two development sample diaphragms were fabricated: one configuration had 12 square-fluted lobes and the second was corrugated. The fluted design (Figure 1) was fabricated and performed the clutching function as planned. The diaphragm was exercised several hundred times and showed no evidence of fatigue. Fabrication of the corrugated diaphragm has not yet been completed.

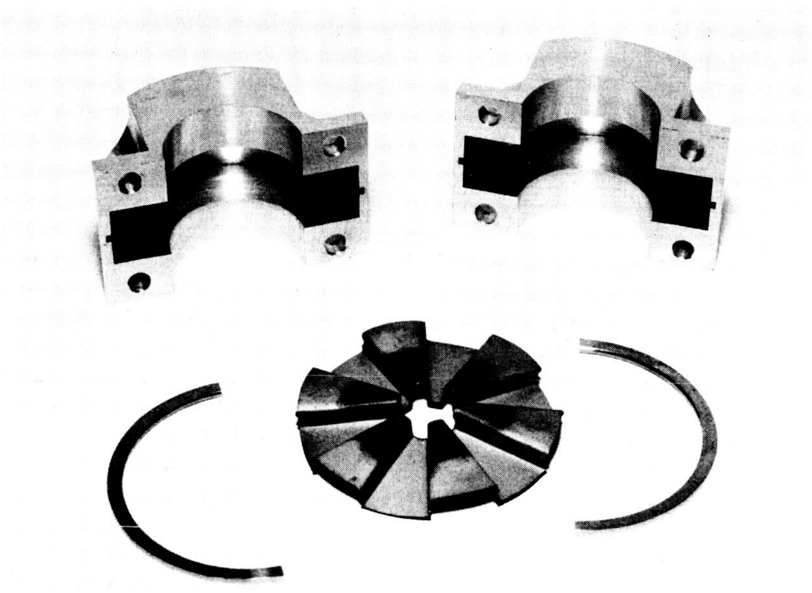
2.3.2.3 Hysteresis Damper Component Design

A working model of the hysteresis damper (Figure 2) was fabricated during the reporting period for engineering evaluation.

During the design of the model, layout drawings were prepared to compare three techniques for providing tension to the wire suspension for the hysteresis damper. The techniques included utilization of a coil spring, a diaphragm, and a "flex-pivot". The flex-pivot scheme was used on the model. A caging concept has been sketched which utilizes redundant bellows motors that are actuated by pyrotechnic charges.



(A) Diaphragm Shown in Text Fixture



(B) Diaphragm Exploded View

Figure 1. 12-Lobe Fluted Diaphragm (Belleville Washer)

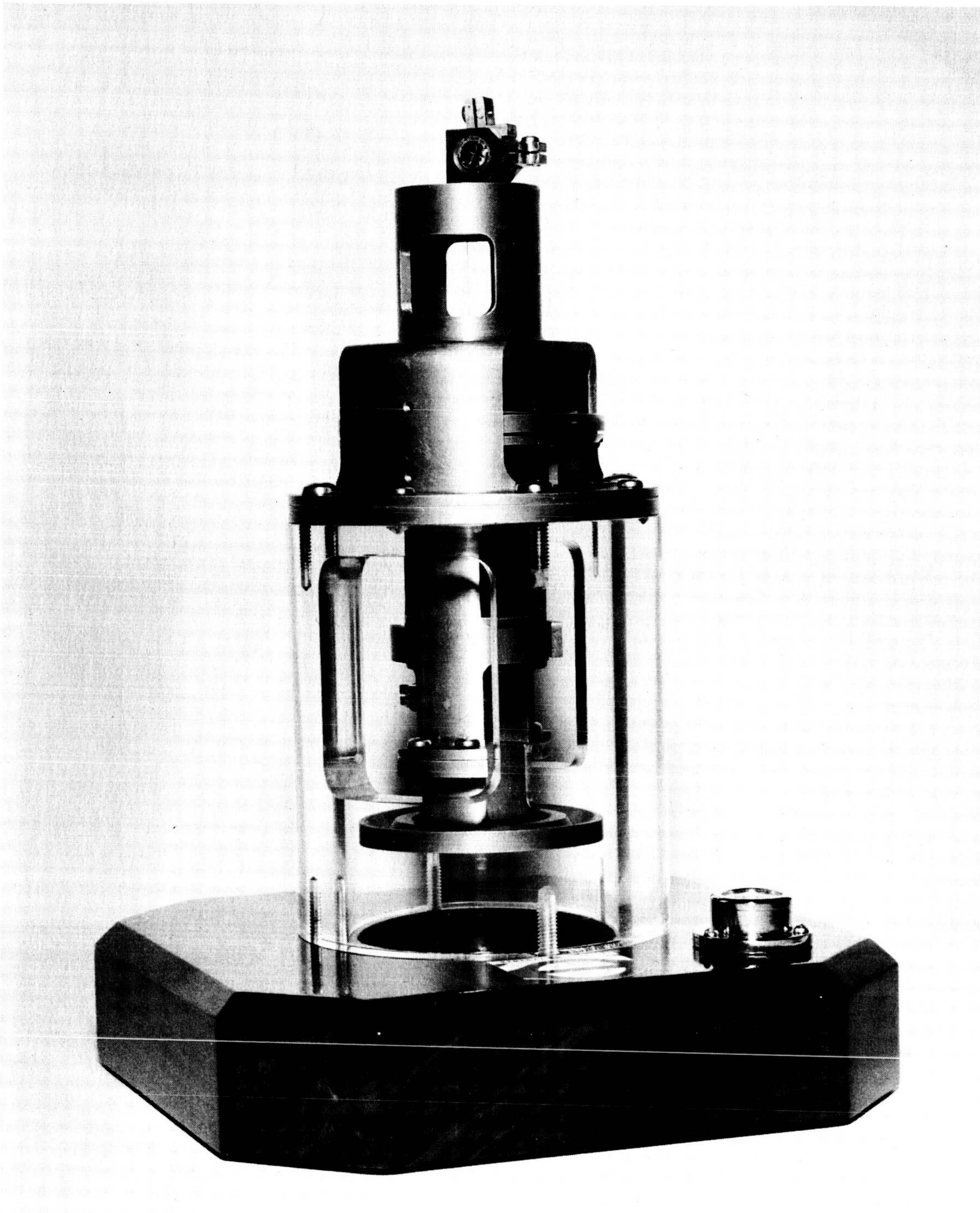


Figure 2. GE Hysteresis Damper Working Model

It is essential that sealed pyrotechnic devices be used inside the CPD because test firing of a cable cutter demonstrated that a considerable amount of debris is liberated that could deteriorate the performance of the angle indicator.

2.3.2.4 Thermal Model Development

A general design for the Thermal Model of the Combination Passive Damper (designated as T-2 in the ATS Program) has been tentatively established. The baseplate will be a simple machined plate with only those fittings necessary for a simulated boom lock pin arrangement and a means of attaching the thermal shield.

Heaters will be installed to simulate the boom angle detector electronics and bulbs. Thermocouples and wire leads will be in accordance with requirements that have already been established.

GE will furnish an integrated test plan for the Thermal Model. Handling and shipping instructions will be established later in the design of the CPD Thermal Model which will be formulated with the view of preventing damage to the thermal coatings. These instructions will be published prior to fabrication.

2.3.2.5 Dynamic Model Development

A configuration for the Dynamic Model (T-3) of the CPD has been tentatively established. This model will be quite similar to the Engineering Unit with deviations to simplify the design for reasons of economy.

2.3.3 DEVELOPMENT ENGINEERING ACTIVITIES

2.3.3.1 Eddy-Current Damper

Tests were conducted to measure the damping coefficient for the eddy-current discs using copper, high purity aluminum, and raw stock aluminum. The damping coefficient of the copper surpassed the design goal of 1,500,000 dyne-cm-sec, but the aluminum discs did not meet the design goal. Performance was not improved appreciably when a thicker aluminum damping disc was used with a larger magnet gap. Another series of tests is planned to measure the effect of increasing the magnetic flux density through the use of longer magnets.

Tests are in progress to measure the amount of hysteresis damping caused by the torsional restraint "crescent" in the eddy current damper.

2.3.3.2 Torsion Wire

Pull tests were performed on the hysteresis damper suspension wire in conjunction with tests to evaluate the use of epoxy as a method of attaching the wire. These tests were successful and indicated that epoxy alone was sufficient to secure the torsion wire. However, the wire will also be clamped under a screw head in the final design.

2.3.3.3 Hysteresis Damper

Tests were performed on discs provided by Bell Telephone Laboratories (BTL) to check the presence of "ripple" (slight variations in damping torque). These tests revealed that "ripple" was present in the BTL discs as well as in GE discs.

2.3.4 SUBCONTRACT ACTIVITIES

2.3.4.1 STL Hysteresis Damper Proposal

A proposal was received from the Space Technology Laboratories (STL) for a hysteresis damper which would be compatible with the Combination Passive Damper.

The proposal was evaluated by engineering, manufacturing and quality control groups.

2.3.4.2 Boom Angle Indicator

Cost details have been discussed with the Dynamics Research Corporation (DRC). They were given initial funding to evaluate the complexity of the boom angle indicator to meet the specification and work statement which were approved by GE and NASA. DRC is to submit a report in February that will define the electronic circuits and supporting analysis, problem areas, and a preliminary mechanical design.

2.3.4.3 Solenoid

G. W. Link Company, Inc. has submitted a quote for the fabrication of the solenoid. However, their force versus travel data was lower than specified (7 pounds at a travel of 0.35 inch compared to 10 pounds at 0.35 inch). To meet specified requirements, the weight, length and diameter of the solenoid would be increased. In order to operate within the force versus travel requirement, temperature limits and wide voltage variation, the solenoid would become much larger than could be contained within the present CPD envelope. Consideration will be given to the use of a power supply with better regulation, thus allowing the use of a physically smaller solenoid.

2.4 ATTITUDE SENSOR SUBSYSTEM

2.4.1 SOLAR ASPECT SENSOR

2.4.1.1 Analysis Activities

An analytical expression for the solar energy distribution at the bottom of the detector reticles has been derived. This expression will be used to determine whether or not a shift in the digit transistion edge occurs due to the extended source of the sun, the diffraction effects of the slit, and the variation of the refractive index of quartz as a function of wavelength. Because of the complexity of the derived expression, it was considered expedient to approximate the expression for the worst case, namely an indication angle of 64 degrees from the normal to the detector. This approximation is being programmed for numerical solution.

2.4.1.2 Sub Contract Activities

The approved Solar Aspect Sensor Component Specification and Work Statement were forwarded to the Adcole Corporation for a final quotation. The changes in the specifications, as compared to those prepared in November, consist of the following:

1. A resistance thermometer was included in the outline drawing for the detector units.
2. The non-operating temperature limit of the detectors was lowered to -160°C.
3. Redundant telemetry outputs were added in accordance with the Hughes Aircraft Company Interface Specification S2-0401.
4. The acceleration levels were increased to reflect the requirements of the synchronous altitude spacecrafts.
5. Analysis of the effects of the derating of all electronic components was added to GE Specification SVS-7325C.
6. A requirement was imposed to purchase 210% of the actual number of approved parts used in the Flight Units in order to allow for the performance degradation of the 1500-hour aging.

The purchase order was approved and placed with Adcole on the basis of the November quotation; but with a cost ceiling for the above items. Adcole was directed to complete the design using High Reliability Electronic piece parts but not to order the parts.

2.4.2 POWER CONTROL UNIT

2.4.2.1 Breadboard Construction

The Power Control Unit developmental breadboard is approximately 95% complete with the exception of the circuits for the Separation Timer. Preliminary functional tests with the engineering test rack were made, as each of the eight 50-pin connectors was completed, to facilitate troubleshooting. The major change to the breadboard during this report period consisted of the redesign of the motor driver circuits to make them compatible with the shunt-wound, d-c motors to be used to drive the primary gravity gradient booms.

2.4.2.2 Mechanical Design

The level of effort on the packaging design of the unit has been kept at a pace which is consistent with the electrical design. Presently six module layouts have been released for manufacture of the Engineering Units. It is expected that five more will have been released by the end of the next report period.

2.4.2.3 Electrical Design

In addition to completing the design of the transistorized reversible motor field controls, the circuit for automatically switching the video output between the TV Cameras was designed and tested. This circuit will alternate the two video signals every 2.64 seconds whenever both cameras are on simultaneously. The circuit is not enabled when only one TV Camera Subsystem is operating. A preliminary design of a series regulator for the damper clutch solenoid was accomplished to alleviate the solenoid design problem caused by the wide variation in the unregulated voltage bus. Consideration is also being given to the circuits required to initially stop the boom extension motors at any distance with an accuracy of ± 3 feet, and to the circuits required to control the speed of the shunt motors.

2.4.2.4 Component Specification

A preliminary draft of the Component Specification for the Power Control Unit, has been prepared. This specification now incorporates all of the requirements previously contained in SVS-7307, SVS-7308, and SVS-7319 which defined the Attitude Sensor Power Control Unit, Gravity Gradient Boom Power Control Unit, and Interface Electronics, respectively. This document will be identified as SVS-7307A.

2.4.3 TV CAMERA SUBSYSTEM

2.4.3.1 Video Bandwidth

The overall bandwidth of the TV Camera Subsystems, including the spacecraft transponder and ground data recording and reproduction, was estimated and the corresponding values of obtainable horizontal and vertical readout accuracy were calculated. The effects of limiting the video output bandwidth of the TV camera to 3.5 mc/s are now being investigated.

2.4.3.2 Testing

A Hallamore TV camera owned by GE was used in testing the boom target design. A Lear-Siegler Camera Subsystem, Model 0431B, was obtained from the manufacture on a short-term loan. Comparison tests of the two cameras are being made so that tests with the Hallamore camera may be later related to the program. Initial testing effort was expended to evaluate different boom target samples. More recent tests have concentrated on observation detection of the best target as a function of signal-to-noise ratio. Filters are being sought to reduce the output bandwidth to 3.5 mc/s.

2.4.3.3 Component Specification

The TV Camera Subsystem Component Specification and work statement were revised and submitted to NASA/ GSFC for review. Final approval is awaiting further definition of

1. the effects of the slow outgassing of the vented unit with respect to a possible corona problem
2. the results of the reduction in video bandwidth to 3.5 mc/ s
3. and more definitive specifications on the linearity and spurious output response.

A general engineering design specification; SVS-7338, was prepared to cover the standards for parts to be used in the TV Camera Subsystem. This specification has been approved and issued.

2.4.3.4 TV Data Reduction

Some of the advantages and disadvantages of automatic vs manual data reduction of the video information was discussed in paragraph 2.4.2.3 of the Fifth Monthly Progrrss Report, GE Document 64SD4390, dated 10 December 1964. During that same period, the Telecine and Film Recording Department of the CBS Television

Network photographed a Marconi resolution chart for using both 16 mm and 35 mm motion picture cameras. The pictures were taken on Eastman Kodak film which is used in the broadcast industry for photographing Kinescope tubes. Results of the test are as follows:

1. Approximately 750 resolution lines were observed on the studio monitor.
2. About 650 lines could be resolved on a microfilm reader from the developed 35 mm film
3. About 450 lines could be resolved from the 16 mm copy.

Both films are reproduced here, the 16 mm in Figure 3(A) and the 35 mm in Figure 3(B) for comparison purposes only, since each will lose additional resolution in the printing process.

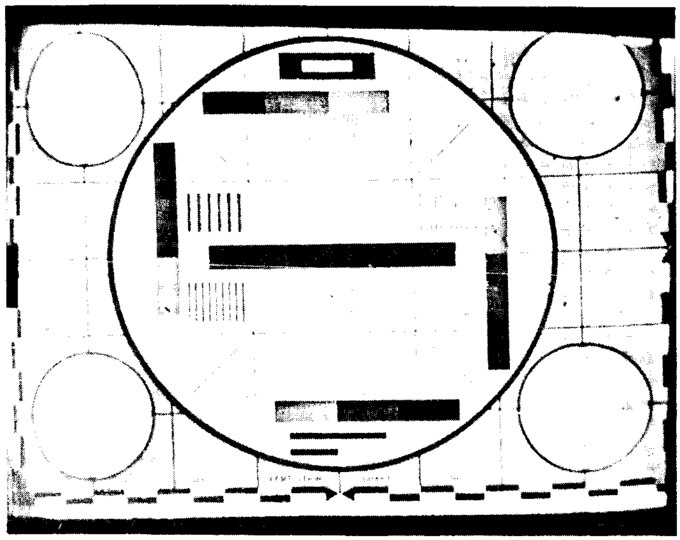
2.5 QUALITY CONTROL

2.5.1 ALIGNMENT TESTING

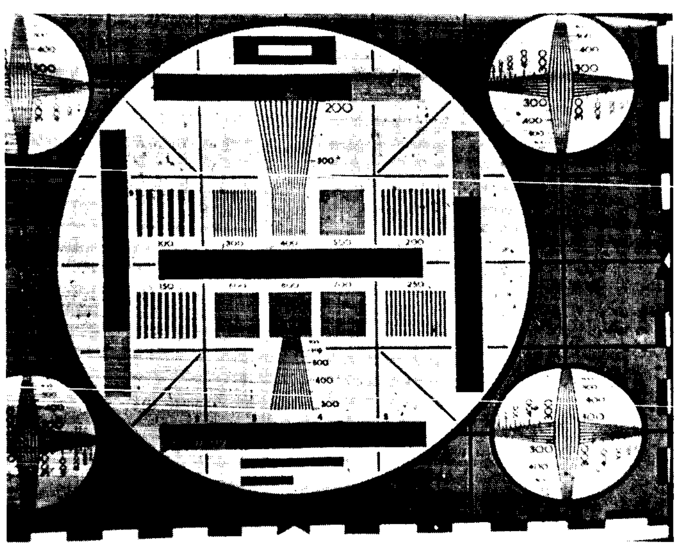
Initial testing of the recommended alignment method produced marginal results principally because of mirror misalignment. To ensure alignment in future tests, a fixture will be designed to hold the mirror in alignment during the bonding process, and an epoxy will be used that cures at room temperature.

2.5.2 SOLAR ASPECT SENSOR TESTING

A test equipment document (TR No. 11004) was issued for the Solar Aspect Sensor which defines the tests that must be performed and the test equipment needed to perform the tests.



(A) 16 mm Eastman Kodak



(B) 35 mm Eastman Kodak

Figure 3. Comparison of Resolution Chart Reproductions

2.5.3 MATERIALS AND PROCESSES

Sample materials are being prepared to determine the thickness of thermal control coatings for several components that require a low emissivity surface.

Adhesives, brazing, and soldering techniques were evaluated to devise a suitable method for joining the damper torsion spring material to its support for the GE model of the hysteresis damper. The adhesives were chosen as the most promising. Engineering models were fabricated and tests demonstrated the ability of the assembly to withstand stresses imposed by spring tension and torsions.

Electronic parts to be used in the Gravity Gradient Stabilization System will be analyzed to determine probable failure mechanisms in support of system reliability analysis.

A run-in procedure was recommended for all bearings to be used in the GGSS. Performance testing will be conducted on all piece parts to establish their suitability for an application.

SECTION 3

RELIABILITY

3.1 RELIABILITY

Emphasis during January was placed on a determination of electrical and mechanical reliability factors in the design of the Combination Passive Damper, Power Control Unit and the Boom Subsystem or to recommend critical reliability areas that should be investigated. Areas of investigation included:

1. Effect of single vs double bridge wires as used in the redundant squib circuit of the CPD
2. Effect on the electrical loops in the Gravity Gradient Boom Subsystem of the emergency operating mode
3. Effect of single cable cutters on the extension of the Damper Boom
4. Possibility of an inadvertent clutching command during dual motor operation.

Progress of the reliability effort on the Primary and Damper Boom Subsystem was investigated at deHavilland during the month.

A comparative reliability analysis was made to determine the risks involved in testing multi-sealed drive of the Boom Subsystem as against testing quantities of the parts that comprise the drive units.

3.2 PARTS PROGRAM

During the month a number of revisions were received to HAC specifications. The corresponding GE and GE subcontractor ordering references were corrected, and the appropriate parts lists were modified. Sets of these revisions were forwarded to NASA/ GSFC.

A review of documents applicable to subcontracting was completed, including SVS-7325 (Standard Parts, Materials and Processes) and SVS-7338 (Standards, Engineering Requirements). The revised specifications were approved by NASA and issued. All parts specifications for which information is complete have been released for use in ordering.

A recent issue of the ATS Requirements Status Sheet indicates that additional revision have been made to HAC specifications and other drawings have been released.

The degradation analysis techniques applied to the 1500-hour burn-in screening of the HAC electronic piece parts has been reviewed. The documents received in November covering this subject are insufficient for process use. Instead of duplicating an expenditure of time, a request has been made through NASA for the additional programming and processing information.

Preliminary specifications have been furnished to the vendor of the Solar Aspect Sensor for solar cells and transformers. These specifications supplement consultation they received on reliability and end-of-life tolerance of parts.

The draft of a microelectronics specification has been prepared for vendor application.

SECTION 4

SCHEDULE

The schedule for the hardware items which will be delivered for use by the spacecraft contractor is shown in Table 1. The schedule is a summary of the detailed PERT networks which have been established and will be maintained for program control.

The schedule is based on the revised program defined in the Work Statement, dated January 11, 1965 and which was transmitted to NASA on January 22, 1965 as part of GE Proposal No. N-20273T, Rev. 1. The schedule assumes that the Government will authorize the procurement of vendor items and high reliability Electronic piece parts, as required, to meet the schedule dates.

TABLE 1. DELIVERY SCHEDULE FOR GRAVITY GRADIENT STABILIZATION SYSTEMS

	1964						1965												1966											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Thermal Model (T_2)										△																				
Dynamic Model (T_3)										△																				
Engineering Model (T_4)													△																	
Prototype Unit																			△											
Flight Unit No. 1 (F_1)																								△						
Flight Unit No. 2 (F_4)																									△					
Flight Unit No. 3 (F_5)																										△				

△ Estimated Shipping Date